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(54) **OPTICAL GLASS**

(71) Applicant: **CDGM GLASS CO., LTD.**, Chengdu, Sichuan (CN)

(72) Inventor: **Bo Kuang**, Sichuan (CN)

(73) Assignee: **CDGM Glass Co., Ltd.**, Chengdu, Sichuan (CN)

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See application file for complete search history.

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Primary Examiner — Noah Wiese
(74) *Attorney, Agent, or Firm* — Caesar Rivise, PC

(57) **ABSTRACT**

The invention provides a kind of high-precision molding optical glass, comprising 0.1-10 wt % of SiO_2, 9-20 wt % of B_2O_3, 20-35 wt % of La_2O_3, 1-8 wt % of ZrO_2, 5-20 wt % of ZnO, 1-10 wt % of Ta_2O_5, 5-15 wt % of Gd_2O_3, 0-2 wt % of TiO_2, 1-10 wt % of Y_2O_3, 1-12 wt % of WO_3, 0-3 wt % of Li_2O and 0-1 wt % of Sb_2O_3. The optical glass provided in the invention features density less than 5.0 g/cm^3, refractive index between 1.80 and 1.85, Abbe number between 40 and 45, transition temperature lower than 600° C., wavelength λ_{80} corresponding to the transmissivity of 80% below 415 nm, and upper limit of devitrification temperature below 1110° C., and is applicable to high-precision molding.

30 Claims, No Drawings

OPTICAL GLASS

TECHNICAL FIELD

The invention relates to a kind of optical glass, in particular to a kind of high-precision molding optical glass with refractive index (nd) ranging from 1.80 to 1.85 and Abbe number ranging from 40 to 45, as well as to the preform and optical element made of said optical glass.

BACKGROUND ART

In recent years, with the development of optoelectronics industry, the optical equipment is required to be miniature and lightweight with high performance. In order to reduce the number of lenses constituting the optical system in optical equipment, more and more aspheric lenses are applied in optical design. At present, high-precision molding is widely used for aspheric lens manufacture, which refers to press molding of glass preform under certain temperature and pressure by high-precision mould with predetermined shape, in order to obtain the final shape or glass products with optical functional surface. The aspheric lenses manufactured with high-precision molding technology usually no longer require grinding and polishing, thereby reducing costs and improving productivity.

In order to replicate the high-precision modular surface on the glass moldings during high-precision molding, the glass preform is required to be pressurized under high temperature (usually 15-40° C. above the softening point temperature of glass). At this point, shaping mould is exposed under high temperature with higher pressure. The surface layer of compression mold remains vulnerable to oxidative attack even under protection. High-precision mould is the major source of high-precision molding costs, so if mould usage does not reach a certain number, the purpose of low cost and high productivity will not be achieved. To prolong the service life of mould and reduce damage to the shaping mould by high-temperature environment, molding temperature shall be reduced as much as possible. Therefore, the transition temperature (Tg) of glass materials is required to be as low as possible.

Chromatic correction is carried out by the combination of high and low dispersion lenses in modern optical imaging system. In recent years, both high and low dispersion lenses apply optical glass with higher refractivity when aberration correction is available, which makes high-refractivity and low-dispersion optical glass become more important in the field of optical glass.

US20030032542 discloses a kind of optical glass, with refractive index above 1.80, Abbe number around 40 but transition temperature of glass over 650° C., which is not suitable to be used as high-precision molding material. Besides, U.S. Pat. No. 5,288,669 discloses a kind of optical glass with refractive index above 1.88 and Abbe number over 29, of which the disadvantage is that the glass has low viscosity and is liable to be refractory.

CONTENTS OF THE INVENTION

A technical problem to be solved by the invention is to provide a kind of high-precision molding optical glass, with density less than 5.0 g/cm^3, refractive index (nd) between 1.80 and 1.85, Abbe number (vd) between 40 and 45, transition temperature lower than 600° C., wavelength λ_{80} corresponding to the transmissivity of 80% below 415 nm, and upper limit of devitrification temperature below 1110° C.

To solve the technical problem, the invention provides a kind of optical glass comprising SiO_2, B_2O_3, La_2O_3, ZrO_2, ZnO, Ta_2O_5, Gd_2O_3, Y_2O_3 and WO_3, with density less than 5.0 g/cm^3, refractive index between 1.80 and 1.85, Abbe number between 40 and 45, transition temperature lower than 600° C., wavelength λ_{80} corresponding to the transmissivity of 80% below 415 nm, and upper limit of devitrification temperature below 1110° C.

Furthermore, said optical glass comprises 0.1-10 wt % of SiO_2, 9-20 wt % of B_2O_3, 20-35 wt % of La_2O_3, 1-8 wt % of ZrO_2, 5-20 wt % of ZnO, 1-10 wt % of Ta_2O_5, 5-15 wt % of Gd_2O_3, 0-2 wt % of TiO_2, 1-10 wt % of Y_2O_3, 1-12 wt % of WO_3, 0-3 wt % of Li_2O and 0-1 wt % of Sb_2O_3.

Furthermore, SiO_2 accounts for 3 to 7%.

Furthermore, B_2O_3 accounts for 14 to 18% and La_2O_3 accounts for 27 to 32%.

Furthermore, ZrO_2 accounts for 2 to 6%.

Furthermore, ZnO accounts for 12 to 17%.

Furthermore, Ta_2O_5 accounts for 2 to 7%.

Furthermore, La_2O_3 accounts for 27 to 32% and Gd_2O_3 is greater than 10% but less than 15%.

Furthermore, Y_2O_3 accounts for 4 to 8%.

Furthermore, the total content of SiO_2, B_2O_3, La_2O_3, ZrO_2, ZnO, Ta_2O_5, Gd_2O_3, Y_2O_3 and WO_3 is greater than 97%.

Furthermore, $La_2O_3/La_2O_3+Gd_2O_3+Y_2O_3$ is less than 0.67.

Furthermore, the weight percentage ratio of Y_2O_3, Gd_2O_3 and La_2O_3 is 1:(1.5-2.5):(5-6).

Furthermore, TiO_2 accounts for 0.2 to 0.5%.

Furthermore, WO_3 accounts for 4 to 7%.

Furthermore, Li_2O accounts for 0.1 to 1%.

A kind of optical glass comprises 0.1-10 wt % of SiO_2, 9-20 wt % of B_2O_3, 20-35 wt % of La_2O_3, 1-8 wt % of ZrO_2, 5-20 wt % of ZnO, 1-10 wt % of Ta_2O_5, 5-15 wt % of Gd_2O_3, 0-2 wt % of TiO_2, 1-10 wt % of Y_2O_3, 1-12 wt % of WO_3, 0-3 wt % of Li_2O and 0-1 wt % of Sb_2O_3.

Furthermore, SiO_2 accounts for 3 to 7%.

Furthermore, B_2O_3 accounts for 14 to 18% and La_2O_3 accounts for 27 to 32%.

Furthermore, ZrO_2 accounts for 2 to 6%.

Furthermore, ZnO accounts for 12 to 17%.

Furthermore, Ta_2O_5 accounts for 2 to 7%.

Furthermore, La_2O_3 accounts for 27 to 32% and Gd_2O_3 is greater than 10% but less than 15%.

Furthermore, TiO_2 accounts for 0.2 to 0.5%.

Furthermore, Y_2O_3 accounts for 4 to 8%.

Furthermore, WO_3 accounts for 4 to 7%.

Furthermore, Li_2O accounts for 0.1 to 1%.

Furthermore, the total content of SiO_2, B_2O_3, La_2O_3, ZrO_2, ZnO, Ta_2O_5, Gd_2O_3, Y_2O_3 and WO_3 is greater than 97%.

Furthermore, $La_2O_3/La_2O_3+Gd_2O_3+Y_2O_3$ is less than 0.67.

Furthermore, the weight percentage ratio of Y_2O_3, Gd_2O_3 and La_2O_3 is 1:(1.5-2.5):(5-6).

A glass preform made of the above-mentioned optical glass.

An optical element made of the above-mentioned optical glass.

An optical apparatus made of the above-mentioned optical glass.

The optical glass provided by the invention is advantageous in that a small amount of Gd_2O_3 and Y_2O_3 and appropriate amount of WO_3 are applied to ensure the optical glass provided in the invention enjoys lower density and excellent devitrification resistance. The optical glass provided in the invention features density (ρ) less than 5.0 g/cm^3, refractive index (nd) between 1.80 and 1.85, Abbe number (vd) between

40 and 45, transition temperature (Tg) lower than 600° C., wavelength λ_{80} corresponding to the transmissivity of 80% below 415 nm, and upper limit of devitrification temperature below 1110° C., and is applicable to high-precision molding.

DESCRIPTION OF EMBODIMENTS

Each component of the optical glass provided by the invention is described hereunder, and the content thereof is represented by wt % unless otherwise stated.

SiO_2, an oxide forming glass, forms irregular continuous network with the structural units of silicon-oxygen tetrahedron and acts as the frame of optical glass. Besides, SiO_2 can maintain the devitrification resistance of glass. When the content of SiO_2 exceeds 10%, the meltability of optical glass will reduce and the softening temperature will increase. Therefore, the content of SiO_2 is 0.1 to 10%, preferably 3 to 7%.

B_2O_3, also an oxide forming glass network, is the major component to obtain stable glass especially in high-refractivity and low-dispersion lanthanide optical glass. When the content of B_2O_3 is less than 9%, it is difficult to obtain stable glass and the devitrification resistance is unsatisfactory; but when the content of B_2O_3 is higher than 20%, the refractive index of glass cannot reach the design goal and the chemical stability of glass will be reduced. Therefore, the content of B_2O_3 is 9 to 20%, preferably 14 to 18%.

La_2O_3, as a main component of high-refractivity and low-dispersion optical glass, can increase the refractive index of glass and not obviously increase the dispersion of glass. In the formulation provided in the invention, the combination of B_2O_3 and La_2O_3 may effectively improve the devitrification resistance and strengthen the chemical stability of glass. However, when the content of La_2O_3 is less than 20%, such effect cannot be achieved; while when the content exceeds 35%, the devitrification resistance of glass is liable to be poor. Therefore, the content of La_2O_3 is 20 to 35%, preferably 27 to 32%.

ZrO_2 can improve the viscosity, hardness, flexibility, refractive index and chemical stability of glass and lower the coefficient of thermal expansion of glass. When the content of ZrO_2 exceeds 8%, devitrified phenomenon will occur and the devitrification resistance of the glass will be weakened. Therefore, the content of ZrO_2 is 1 to 8%, preferably 2 to 6%.

ZnO, as a key component to form low-melting-point optical glass, can reduce the coefficient of thermal expansion of glass and improve the chemical stability, thermal stability and refractive index of glass. When the content of ZnO is greater than 20%, the devitrification of optical glass increases and dispersion is obviously enlarged, so it will be difficult to obtain the Abbe number (vd) above 40; while when the content of ZnO is less than 5%, the transition temperature of optical glass increases, so it will be difficult to obtain the transition temperature under 600° C. Therefore, the content of ZnO is preferably 5 to 20%, more preferably 12 to 17%.

Ta_2O_5 can effectively improve the refractive index, chemical stability and devitrification resistance of glass. However, if its content is too little, the effects are not obvious; while if its content is excessive, it will be hard to maintain the optical constant as shown in the present invention. Therefore, Ta_2O_5 is preferably 1 to 10%, more preferably 2 to 7% in terms of cost.

Gd_2O_3 can enhance the refractive index of glass and not obviously increase the dispersion of glass. In addition, Gd_2O_3 can effectively improve the devitrification resistance and strengthen the chemical stability of glass. The devitrification resistance of glass can be improved by mixing certain amount of Gd_2O_3 and La_2O_3. When the content of Gd_2O_3 is less than 5%, the effects are not obvious; while when the content of Gd_2O_3 exceeds 15%, the devitrification resistance of glass is liable to be poor. Therefore, the content of Gd_2O_3 is 5 to 15%, more preferably greater than 10% but less than 15%.

Y_2O_3 is a high-refractivity and low-dispersion component, but it may significantly enhance the transition temperature of glass and is easily to raise the upper limit of devitrification temperature of glass. As rare-earth oxide raw materials, the price ration of Y_2O_3, La_2O_3 and Gd_2O_3 is approximately 1:1:3.5. Through researches, the inventor found that by using certain amount of Y_2O_3 to replace Gd_2O_3, when the weight percentage ratio of Y_2O_3, Gd_2O_3 and La_2O_3 is 1:(1.5-2.5):(5-6) and especially when such ratio is around 1:2:6, low cost can be better achieved, the transition temperature and upper limit of devitrification temperature of glass will not be significantly increased, and the effects required by high-precision molding can be realized. Therefore, the content of Y_2O_3 is preferably 1 to 10%, more preferably 4 to 8%.

TiO_2 can effectively increase the refractive index of glass. In the present invention, adding a certain amount of TiO_2 can also prevent the glass from discoloration due to sun exposure, but if the content is too high, the glass will be stained and the devitrification of glass tends to be increased significantly. Therefore, the content of TiO_2 is 0 to 2%, preferably 0.2 to 0.5%.

WO_3 is mainly used to maintain the optical constant in glass and improve glass devitrification, but if the content of WO_3 is too high, the transmissivity of glass will reduce, staining degree will increase and devitrification property is liable to be poor. Therefore, the content of WO_3 is preferably 1 to 12%, more preferably 4 to 7%.

In order to better obtain the optical glass provided in the invention, the total content of SiO_2, B_2O_3, La_2O_3, ZrO_2, ZnO, Ta_2O_5, Gd_2O_3, Y_2O_3 and WO_3 is preferably greater than 97%, and $La_2O_3/La_2O_3+Gd_2O_3+Y_2O_3$ preferably less than 0.67 in the invention.

Li_2O can effectively reduce the transition temperature of glass and melting temperature during glass production. If the content of Li_2O is too high, the devitrification resistance is liable to be degraded and it will be difficult to achieve the target optical constants. Therefore, the content of Li_2O is preferably 0 to 3%, more preferably 0.1 to 1%.

Optionally, Sb_2O_3 can be added as fining agent of glass in the glass melting process, usually with content at 0 to 1%. If the content of Sb_2O_3 is too high, the platinum vessel will be greatly damaged.

In the following paragraphs, the performance of optical glass provided in this invention will be described:

Refractive index (nd) refers to annealing value from −2° C./h to −6° C./h. The refractive index and Abbe number are measured as per the *Test Methods of Colorless Optical Glass—Refractive Index and Coefficient of Dispersion* (*GB/T* 7962.1-1987).

Transition temperature (Tg) is tested as per *Test Methods of Colorless Optical Glass—Linear Thermal Expansion Coefficient, Transition Temperature and Yield Point Temperature* (*GB/T* 7962.16-1987), namely, placing the tested sample in a certain temperature range, extending straight lines of a low-temperature region and a high-temperature region on an expansion curve of the tested sample for each 1 degree centigrade rise in temperature, intersecting the straight lines, wherein the temperature corresponding to the intersection point is the Tg.

Density is tested as per *Colorless Optical Glass Test Methods—Density* (*GB/T* 7962.20-1987).

The glass is processed into a sample which is 10 mm plus or minus 0.1 mm thick to test the wavelength λ_{80} corresponding to the transmissivity of 80%.

The devitrification property of the glass is measured by gradient-furnace method which comprises the following steps: processing the glass into samples (180*10*10 mm), polishing lateral sides, placing the samples into a furnace with temperature gradient, taking out the samples after keeping the temperature for 4 hours, and observing the devitrification of glass under a microscope, wherein the maximum temperature corresponding to the appearance of crystals is the upper limit of devitrification temperature of glass. The lower the upper limit of devitrification temperature of glass is, the stronger the stability of glass under high temperature will be and the better production process performance will achieve.

The test shows that the optical glass provided by the invention has the following properties that the density is less than 5.0 g/cm^3, refractive index (nd) ranges from 1.80 to 1.85, Abbe number (vd) ranges from 40 to 45, transition temperature (Tg) is lower than 600° C., the wavelength λ_{80} corresponding to the transmissivity of 80% is less than 415 nm, and the upper limit of devitrification temperature below 1110° C.

EMBODIMENTS

In the following paragraphs, the embodiments of high-precision molding optical glass provided in the present invention will be described. What shall be noted is that these embodiments do not limit the scope of this invention.

The optical glasses (embodiments 1-40) shown in Tables 1 to 4 are formed by weighting based on the proportions of each embodiment in Tables 1 to 4, mixing the ordinary raw materials for optical glass (such as oxide, hydroxide, carbonate, nitrate and fluoride), placing the mixed raw materials in a platinum crucible, melting under the temperature of 1100 to 1300° C., obtaining homogeneous molten glass without bubbles and undissolved substances after melting, clarification, stirring and homogenization, shaping the molten glass in a mould and perform annealing.

Tables 1 to 4 indicate the composition, refractive index (nd), Abbe number (vd), density (ρ) and glass transition temperature (Tg) of embodiments 1~40 of the invention. The composition of each component is represented by wt % in such tables.

TABLE 1

	Embodiments									
Composition	1	2	3	4	5	6	7	8	9	10
SiO_2	0.12	9.88	7.36	3.03	6.87	6.2	8.32	5.94	6.34	4.35
B_2O_3	19.97	9.03	16.97	17.86	15.2	15.4	12.41	15.05	16.54	17.32
La_2O_3	29.46	34.86	23.03	29.8	31.87	28.5	29.8	31.25	28.98	28.22
ZrO_2	7.88	1.11	6.21	2.12	5.86	4.7	5.7	4.39	3.28	4.85
ZnO	5.12	19.78	18.56	16.91	11.23	15.1	16.2	15.47	12.22	16.1
Ta_2O_5	9.78	1.13	8.69	2.76	6.76	4.5	4.39	5.64	4.91	6.25
TiO_2		1.86	0.45	0.48	0.21		0.35	0.21	0.36	
Gd_2O_3	14.85	5.05	13.45	14.84	10.05	12.5	11.33	10.26	12.54	11.09
Y_2O_3	8.86	5.45	3.04	7.89	4.12	6.0	4.6	6.37	7.52	5.34
WO_3	1.12	11.85	1.04	4.06	6.92	6.6	6.5	4.58	6.31	5.97
Li_2O	2.84		1.2	0.25	0.91	0.5	0.4	0.84	0.6	0.51
Sb_2O_3	0.02	0.03	0.01	0.04	0.01		0.02	0.03	0.01	0.05
nd	1.835	1.849	1.802	1.831	1.828	1.822	1.821	1.828	1.820	1.824
vd	44.8	40.1	45.0	43.3	43.0	42.5	42.3	43.1	42.2	42.3
Tg(° C.)	597	585	550	598	588	596	597	572	598	591
λ80	386	412	395	392	396	397	395	390	398	396
Devitrification temperature (° C.)	1100	1085	1105	1070	1100	1090	1085	1100	1085	1085
ρ (g/cm^3)	4.99	4.93	4.80	4.95	4.89	4.90	4.89	4.92	4.90	4.90

TABLE 2

	Embodiments									
Composition	11	12	13	14	15	16	17	18	19	20
SiO_2	2.12	8.38	6.64	6.81	5.87	6.16	4.91	6.34	5.2	6.05
B_2O_3	17.37	10.83	14.77	17.1	17.06	16.34	17.03	16.93	16.7	16.38
La_2O_3	30.52	28.69	29	26.88	27.62	29.14	28.17	26.63	26.45	26.28
ZrO_2	6.8	7.1	5.39	3.33	4.09	4.08	3.7	2.69	5.08	5.39
ZnO	15.12	17.55	14.67	15.2	15.47	16.22	14.82	15.62	14.35	15.71
Ta_2O_5	3.78	5.38	6.27	5.38	4.39	2.91	6.22	5.33	6.08	4.35
TiO_2			0.46	0.27	0.37	0.29	0.35	0.41	0.44	0.28
Gd_2O_3	13.5	29.5	11.28	12.35	14.16	13.71	12.37	13.28	13.82	12.08
Y_2O_3	8.34	3.68	3.45	6.57	6.44	4.33	6.51	5.38	6.92	6.34
WO_3	1.62	8.35	7.31	5.67	3.91	6.48	5.38	6.74	4.39	6.47
Li_2O	0.81	0.54	0.76	0.44	0.62	0.34	0.54	0.65	0.57	0.67
Sb_2O_3	0.02	0.01	0.02	0.03	0.02	0.04	0.02	0.01	0.03	0.02
nd	1.841	1.841	1.842	1.801	1.813	1.809	1.825	1.808	1.819	1.813
vd	44.1	40.5	40.5	41.6	43.5	42.1	42.3	41.9	43.0	42.8
Tg(° C.)	575	582	580	592	595	594	590	581	593	580
λ80	390	395	406	392	391	398	394	396	392	395

TABLE 2-continued

Composition	Embodiments 11	12	13	14	15	16	17	18	19	20
Devitrification temperature (° C.)	1100	1100	1100	1085	1095	1085	1090	1090	1090	1100
ρ (g/cm^3)	4.96	4.94	4.95	4.90	4.87	4.85	4.89	4.85	4.88	4.86

TABLE 3

Composition	Embodiments 21	22	23	24	25	26	27	28	29	30
SiO_2	5.1	4.85	5.1	5.02	5.12	5.13	5.22	4.88	5.11	5.2
B_2O_3	17.2	16.11	15.83	16.04	15.99	16.2	15.87	16.17	16.15	16.49
La_2O_3	29.07	29.92	30.51	29.48	30.18	29.4	29.82	29.74	29.63	29.49
ZrO_2	4.01	3.96	4.26	4.03	4.25	4.08	4.32	4.08	4.31	3.88
ZnO	15.34	15.21	14.88	15.11	14.92	15.03	14.95	15.02	14.98	15.2
Ta_2O_5	5.22	5.46	4.86	5.04	4.87	5.14	4.95	5.12	4.88	5.1
TiO_2	0.25	0.31	0.27	0.32	0.38	0.36	0.28	0.33	0.29	0.34
Gd_2O_3	12.3	12.24	12.25	12.61	11.96	12.55	12.52	12.53	12.51	12.39
Y_2O_3	5.86	6.04	5.93	6.22	6.31	6.2	6.04	6.14	6.05	5.84
WO_3	5.12	5.32	5.6	5.61	5.48	5.42	5.48	5.51	5.62	5.56
Li_2O	0.53	0.6	0.51	0.52	0.54	0.49	0.55	0.48	0.47	0.51
Sb_2O_3	0.02	0.01	0.02	0.02	0.03	0.01	0.01	0.03	0.02	0.02
nd	1.816	1.830	1.829	1.828	1.827	1.824	1.830	1.829	1.827	1.821
vd	42.5	42.6	42.7	42.6	42.8	42.6	42.7	42.7	42.7	42.4
Tg(° C.)	593	591	595	595	594	596	594	596	597	594
λ80	389	395	396	395	396	394	395	396	395	393
Devitrification temperature (° C.)	1090	1095	1090	1090	1090	1090	1090	1090	1090	1090
ρ (g/cm^3)	4.86	4.92	4.92	4.91	4.91	4.91	4.92	4.92	4.91	4.90

TABLE 4

Composition	Embodiments 31	32	33	34	35	36	37	38	39	40
SiO_2	5.0	4.84	5.0	5.0	5.3	5.2	5.45	4.9	5.10	5.0
B_2O_3	17.2	16.10	15.95	16.05	15.8	16.0	15.9	16.2	16.15	16.7
La_2O_3	31.8	30.0	32.55	32.2	32.4	31.0	30.0	30.0	28.95	34.8
ZrO_2	4.00	3.95	4.26	4.05	4.25	3.9	5.30	4.00	4.30	3.04
ZnO	15.35	15.20	14.9	15.10	14.80	15.05	14.95	13.85	15.0	14.2
Ta_2O_5	5.00	5.65	4.85	5.1	4.85	5.0	6.5	5.0	4.9	4.0
TiO_2	0.25	0.30	0.27	0.32	0.38	0.35	0.28	0.24	0.29	0.35
Gd_2O_3	10.6	12.0	10.25	9.65	10.8	11.85	10.0	15.0	13.75	11.6
Y_2O_3	5.3	6.0	5.85	6.4	5.4	5.9	5	6.0	5.5	5.8
WO_3	5.00	5.35	5.6	5.60	5.45	5.25	6.06	4.4	5.54	4.0
Li_2O	0.50	0.6	0.50	0.51	0.55	0.49	0.55	0.4	0.50	0.50
Sb_2O_3		0.01	0.02	0.02	0.02	0.01	0.01	0.01	0.02	0.01
nd	1.819	1.831	1.830	1.828	1.827	1.823	1.824	1.830	1.826	1.830
vd	42.6	42.6	42.4	42.3	42.8	42.6	42.7	42.9	42.7	43.1
Tg(° C.)	595	590	595	595	594	596	593	599	596	598
λ80	389	395	396	395	396	393	395	385	395	390
Devitrification temperature (° C.)	1080	1090	1090	1090	1085	1085	1080	1085	1085	1095
ρ (g/cm^3)	4.87	4.92	4.92	4.91	4.91	4.90	4.90	4.93	4.90	4.93

As illustrated in the above embodiments, the optical glass provided by the invention is characterized by density (ρ) less than 5.0 g/cm^3, refractive index (nd) ranging from 1.80 to 1.85, Abbe number (vd) ranging from 40 to 45, transition temperature (Tg) lower than 600° C., wavelength λ_{80} corresponding to the transmissivity of 80% below 415 nm and upper limit of devitrification temperature below 1110° C., and is applicable to high-precision molding.

The invention claimed is:

1. An optical glass, comprising SiO_2, B_2O_3, La_2O_3, ZrO_2, ZnO, Ta_2O_5, Gd_2O_3, Y_2O_3 and WO_3, with density less than 5.0 g/cm^3, refractive index between 1.80 and 1.85, Abbe number between 40 and 45, transition temperature lower than 600° C., wavelength λ_{80} corresponding to the transmissivity of 80% below 415 nm, and upper limit of devitrification temperature below 1110° C., wherein $La_2O_3/La_2O_3+Gd_2O_3+Y_2O_3$ is less than 0.67, and Gd_2O_3 content is 5-15 wt %.

2. The optical glass according to claim **1**, comprising 0.1-10 wt % of SiO_2, 9-20 wt % of B_2O_3, 20-35 wt % of La_2O_3, 1-8 wt % of ZrO_2, 5-20 wt % of ZnO, 1-10 wt % of Ta_2O_5, 5-15 wt % of Gd_2O_3, 0-2 wt % of TiO_2, 1-10 wt % of Y_2O_3, 1-12 wt % of WO_3, 0-3 wt % of Li_2O and 0-1 wt % of Sb_2O_3.

3. The optical glass according to claim **1**, wherein SiO_2 accounts for 3 to 7%.

4. The optical glass according to claim **1**, wherein B_2O_3 accounts for 14 to 18% and La_2O_3 accounts for 27 to 32%.

5. The optical glass according to claim **1**, wherein ZrO_2 accounts for 2 to 6%.

6. The optical glass according to claim **1**, wherein ZnO accounts for 12 to 17%.

7. The optical glass according to claim **1**, wherein Ta_2O_5 accounts for 2 to 7%.

8. The optical glass according to claim **1**, wherein La_2O_3 accounts for 27 to 32% and Gd_2O_3 is greater than 10% but less than 15%.

9. The optical glass according to claim **1**, wherein WO_3 accounts for 4 to 7%.

10. The optical glass according to claim **1**, wherein Y_2O_3 accounts for 4 to 8%.

11. The optical glass according to claim **1**, wherein the total content of SiO_2, B_2O_3, La_2O_3, ZrO_2, ZnO, Ta_2O_5, Gd_2O_3, Y_2O_3 and WO_3 is greater than 97%.

12. The optical glass according to claim **1**, wherein the weight percentage ratio of Y_2O_3, Gd_2O_3 and La_2O_3 is 1:(1.5-2.5):(5-6).

13. The optical glass according to claim **2**, wherein TiO_2 accounts for 0.2 to 0.5%.

14. The optical glass according to claim **2**, wherein Li_2O accounts for 0.1 to 1%.

15. An optical glass, comprising 0.1-10 wt % of SiO_2, 9-20 wt % of B_2O_3, 20-35 wt % of La_2O_3, 1-8 wt % of ZrO_2, 5-20 wt % of ZnO, 1-10 wt % of Ta_2O_5, 5-15 wt % of Gd_2O_3, 0-2 wt % of TiO_2, 1-10 wt % of Y_2O_3, 1-12 wt % of WO_3, 0-3 wt % of Li_2O and 0-1 wt % of Sb_2O_3, wherein $La_2O_3/La_2O_3+Gd_2O_3+Y_2O_3$ is less than 0.67.

16. The optical glass according to claim **15**, wherein SiO_2 accounts for 3 to 7%.

17. The optical glass according to claim **15**, wherein B_2O_3 accounts for 14 to 18% and La_2O_3 accounts for 27 to 32%.

18. The optical glass according to claim **15**, wherein ZrO_2 accounts for 2 to 6%.

19. The optical glass according to claim **15**, wherein ZnO accounts for 12 to 17%.

20. The optical glass according to claim **15**, wherein Ta_2O_5 accounts for 2 to 7%.

21. The optical glass according to claim **15**, wherein La_2O_3 accounts for 27 to 32% and Gd_2O_3 is greater than 10% but less than 15%.

22. The optical glass according to claim **15**, wherein TiO_2 accounts for 0.2 to 0.5%.

23. The optical glass according to claim **15**, wherein Y_2O_3 accounts for 4 to 8%.

24. The optical glass according to claim **15**, wherein WO_3 accounts for 4 to 7%.

25. The optical glass according to claim **15**, wherein Li_2O accounts for 0.1 to 1%.

26. The optical glass according to claim **15**, wherein the total content of SiO_2, B_2O_3, La_2O_3, ZrO_2, ZnO, Ta_2O_5, Gd_2O_3, Y_2O_3 and WO_3 is greater than 97%.

27. The optical glass according to claim **15**, wherein the weight percentage ratio of Y_2O_3, Gd_2O_3 and La_2O_3 is 1:(1.5-2.5):(5-6).

28. A glass preform made of the optical glass according to claims **1**.

29. An optical element made of the optical glass according to claim **1**.

30. An optical apparatus made of the optical glass according to claim **1**.

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